

CLAIMS

What is claimed is:

- 1 1. A processor implemented data processing method comprising:
 - 2 identifying a first plurality of regions within a first recursively
 - 3 partitioned/nested geometric structure that correspond to a first plurality of
 - 4 normalized multi-dimensional data of a first normalized multi-dimensional data
 - 5 space, the first recursively partitioned/nested geometric structure being
 - 6 corresponding to the first normalized multi-dimensional data space;
 - 7 determining corresponding first graphing values for said first corresponding
 - 8 regions within said first recursively partitioned/nested geometric structure
 - 9 determined for said first normalized multi-dimensional data of said first normalized
 - 10 multi-dimensional data space;
 - 11 associating corresponding first visual attributes with said first corresponding
 - 12 regions within said first recursively partitioned/nested geometric structure, based at
 - 13 least in part on corresponding ones of said determined first graphing values; and
 - 14 displaying said first recursively partitioned/nested geometric structure, visually
 - 15 differentiating said first corresponding regions based at least in part on
 - 16 corresponding ones of said associated first visual attributes.
- 1 2. The method of claim 1, wherein each of said first normalized multi-
- 2 dimensional data of said first normalized multi-dimensional data space comprises a
- 3 plurality of relative coordinate values, and the method further comprises constructing
- 4 a polynary string to represent each of said first normalized multi-dimensional data
- 5 and its corresponding one of said first regions within said first recursively

6 partitioned/nested geometric structure in accordance with the relative coordinate
7 values.

1 3. The method of claim 2, wherein said constructing of a polynary string to
2 represent each of said first normalized multi-dimensional data and its corresponding
3 one of said first regions within said first recursively partitioned/nested geometric
4 structure in accordance with the relative coordinate values comprises selecting a
5 symbol as the next symbolic member of the polynary string based on which of the
6 relative coordinate values is the current highest relative coordinate value.

1 4. The method of claim 3, wherein said constructing of a polynary string to
2 represent each of said first normalized multi-dimensional data and its corresponding
3 one of said first regions within said first recursively partitioned/nested geometric
4 structure in accordance with the relative coordinate values further comprises
5 reducing the highest relative coordinate value in by an amount (G), upon each
6 selection, and reducing the amount (G) after each reduction.

1 5. The method of claim 4, wherein the amount (G) initially equals $1 - F$, and
2 thereafter reduced each time by $G^*(1 - F)$, where F equals $(n - 1)/n$, and n equals
3 the number of relative coordinate values.

1 6. The method of claim 2, wherein said determining of corresponding first
2 graphic values comprises determining frequencies of occurrence of the various
3 polynary strings of said first normalized multi-dimensional data, and assigning the
4 determined frequencies of occurrence to the corresponding first regions within the

5 first recursively partitioned/nested geometric structure as the determined first
6 graphing values of the corresponding first regions.

1 7. The method of claim 1, wherein said determining of corresponding first
2 graphic values comprises assigning first output values corresponding to the first
3 normalized multi-dimensional data as the determined first graphing values of the
4 corresponding first regions within the first recursively partitioned/nested geometric
5 structure.

1 8. The method of claim 7, wherein said determining of corresponding first
2 graphic values further comprises computing said first output values.

1 9. The method of claim 8, wherein each of said first normalized multi-
2 dimensional data of said first normalized multi-dimensional data space comprises a
3 polynary string having a plurality of symbols, encoding a plurality of relative
4 coordinate values, and said computing of the first output values comprises
5 for each constituting symbols of a polynary string, summing one or more
6 appearance values corresponding to one or more appearances of the particular
7 symbol in the polynary string, and adding the sum to an average residual relative
8 coordinate value.

1 10. The method of claim 9, wherein each appearance value corresponding to an
2 appearance of a particular symbol is dependent on the position of the particular
3 appearance of the particular symbol in the polynary string.

1 11. The method of claim 10, wherein each appearance value corresponding to an
2 appearance of a particular symbol is equal to a positional value associated with the
3 position of the particular appearance in the polynary string.

1 12. The method of claim 11, wherein
2 each positional value equals to $(1 - F) \times F^{**}(k - 1)$, and
3 the average residual relative coordinate value equals $(1 - F) \times F^{**}K$,
4 where F equals $(n - 1)/n$,
5 k denotes a position in a polynary string,
6 n equals the number of relative coordinate values, and
7 K equals the length of the polynary string.

1 13. The method of claim 2, wherein the method further comprises
2 receiving a first zooming specification comprising one or more of said
3 polynary string constituting symbols;
4 excluding a first subset of said first regions based at least in part on said
5 received first zooming specification; and
6 repeating said displaying for the remaining ones of said first regions in an
7 expanded manner.

1 14. The method of claim 13, wherein the method further comprises
2 receiving a second zooming specification comprising one or more additional
3 ones of said polynary string constituting symbols;
4 excluding a second subset of said remaining ones of said first regions based
5 at least in part on said received second zooming specification; and
6 repeating said displaying for the remaining ones of said first regions.

1 15. The method of claim 14, wherein the method further comprises
2 receiving an unzoom specification;
3 restoring the remaining ones of said first regions to re-include said excluded
4 second subset of said first regions; and
5 repeating said displaying for the remaining ones of said first regions.

1 16. The method of claim 13, wherein the method further comprises
2 receiving an unzoom specification;
3 restoring the remaining ones of said first regions to re-include said excluded
4 first subset of said first regions; and
5 repeating said displaying for said first regions.

1 17. The method of claim 1, wherein said associating comprises for each of said
2 first regions, associating a selected one of a plurality of symbols with the region
3 based at least in part on the determined graphing value of the region.

1 18. The method of claim 1, wherein said associating comprises for each of said
2 first regions, associating a selected one of a plurality of color attributes with the
3 region based at least in part on the determined graphing value of the region.

1 19. The method of claim 1, wherein said associating comprises for each of said
2 first regions, associating a selected one of a plurality of colored geometric primitives
3 with the region based at least in part on the determined graphing value of the region.

1 20. The method of claim 1, wherein said associating comprises for each of said
2 first regions, associating a selected blending of a plurality of colors with the region
3 based at least in part on contributions to the determined graphing value of the
4 region.

1 21. The method of claim 1, wherein said first regions correspond to all
2 constituting regions of the first recursively partitioned/nested geometric structure,
3 said first normalized multi-dimensional data are values of independent variables of a
4 function, and said first graphing values are corresponding values of a dependent
5 variable of the function.

1 22. The method of claim 1, wherein the method further comprises
2 identifying a second plurality of regions within a second recursively
3 partitioned/nested geometric structure that correspond to a second plurality of
4 normalized multi-dimensional data of a second normalized multi-dimensional data
5 space, the second recursively partitioned/nested geometric structure being
6 corresponding to the second normalized multi-dimensional data space;
7 determining corresponding second graphing values for said second
8 corresponding regions within said second recursively partitioned/nested geometric
9 structure determined for said second normalized multi-dimensional data of said
10 second normalized multi-dimensional data space;
11 associating corresponding second visual attributes with said second
12 corresponding regions within said second recursively partitioned/nested geometric
13 structure, based at least in part on corresponding ones of said determined second
14 graphing values; and

15 displaying said second recursively partitioned/nested geometric structure,
16 visually differentiating said second corresponding regions based at least in part on
17 corresponding ones of said associated second visual attributes.

1 23. The method of claim 22, wherein said first and second recursively
2 partitioned/nested geometric structures are displayed in a manner such that both
3 recursively partitioned/nested geometric structures are visible concurrently.

1 24. The method of claim 23, wherein each of said first and second normalized
2 multi-dimensional data of said first and second normalized multi-dimensional data
3 spaces comprises a polynary string having a plurality of symbols, encoding a
4 plurality of relative coordinate values, the method further comprises
5 receiving a first zooming specification comprising one or more of said
6 polynary string constituting symbols;
7 excluding a first subset of said first regions based at least in part on said
8 received first zooming specification;
9 excluding a second subset of said second regions based at least part on the
10 removed ones of said first regions; and
11 repeating said displaying for the remaining ones of said first and second
12 regions.

1 25. The method of claim 22, wherein said first and second normalized multi-
2 dimensional data are values of first and second input variables.

1 26. The method of claim 22, wherein said first normalized multi-dimensional data
2 are values of input variables, and said second normalized multi-dimensional data
3 are values of corresponding output variables.

1 27. The method of claim 1, wherein the method further comprises computing a
2 location for a centroid for each of a plurality primitive elements of the geometric
3 structure.

1 28. The method of claim 27, wherein coordinates (x_p, y_p) of the location of each
2 centroid is computed as follows:

3
$$X_p = X_c + R * \sum_{k=1}^K V(N, k) * C(N, m[L_k])$$

4
$$Y_p = Y_c + R * \sum_{k=1}^K V(N, k) * S(N, m[L_k])$$

5 where:

6 (X_c, Y_c) are coordinate values of the geometric structure's centroid;

7 R is a radius extending from the geometric structure's centroid to an
8 outermost vertex of the geometric structure;

9 $V(N, k)$ is $w^*(1 - w)^{**}(k - 1)$ where $w = 1/(1 + \sin(\pi/N))$;

10 $m[L_k]$ is outer vertex number (1, 2, ..., N) assigned to the kth symbol
11 appearing in a corresponding polynary string;

12 $C(N, m[L_k]) = \cos(a * \pi)$; and

13 $S(N, m[L_k]) = \sin(a * \pi)$ [where $a = (5*N - 4*m[L_k])/(2*N)$].

1 29. The method of claim 28, wherein the K values of $V(N, k)$ are computed once
2 responsive to a specification of N.

1 30. The method of claim 28, wherein at least the N values of $C(N, m[L_k])$ or the N
2 values of $S(N, m[L_k])$ are computed once responsive to a specification of N.

1 31. A processor implemented data processing method for generating a polynary
2 string representation for an entity defined by n relative coordinate values, n being an
3 integer, comprising:

4 associating n symbolic representations with said n relative coordinate values;
5 and

6 selecting the symbolic representation corresponding to the highest relative
7 coordinate value as the first constituting member of the polynary string
8 representation.

1 32. The method of claim 31, wherein the method further comprises
2 computing a constant value (F) by dividing $(n - 1)$ by n; and
3 computing a variable value (G) by subtracting F from 1;
4 subtracting G from the current highest relative coordinate value; and
5 selecting the symbolic representation corresponding to the current highest
6 relative coordinate value as the next constituting member of the polynary string
7 representation.

1 33. The method of claim 32, wherein the method further comprises
2 multiplying the current value of G by F;
3 subtracting G from the current highest relative coordinate value; and
4 selecting the symbolic representation corresponding to the current highest
5 relative coordinate value as the next constituting member of the polynary string
6 representation.

1 34. The method of claim 33, wherein the method further comprises repeating
2 said multiply, subtracting and selecting operations set forth in claim 29.

1 35. The method of claim 31, wherein said symbolic representation comprises a
2 letter.

1 36. The method of claim 31, wherein said symbolic representation comprises a
2 special character.

1 37. A processor implemented data processing method for generating a relative
2 coordinate value for an constituting variable of an entity, the entity being
3 represented by a polynary string representation having a plurality of symbolic
4 members representing the constituting variables, the method comprising:

5 determining appearance positions of appearance instances of the symbolic
6 members in said polynary string representation;

7 summing positional values corresponding to the appearance instances of the
8 symbolic members in said polynary string representation; and

9 adding the sum to an average residual relative coordinate value.

1 38. The method of claim 37, wherein
2 each positional value equals to $(1 - F) \times F^{**}(k - 1)$, and
3 the average residual relative coordinate value equals $(1 - F) \times F^{**}K$,
4 where F equals $(n - 1)/n$,
5 n equals the number of coordinate values,
6 k denotes a position in the polynary string representation; and

7 K equals the length of the polynary string.

1 39. An apparatus comprising:

2 storage medium having stored therein programming instructions designed to
3 enable the apparatus to

4 identify a first plurality of regions within a first recursively

partitioned/nested geometric structure that correspond to a first

6 plurality of normalized multi-dimensional data of a first normalized

7 multi-dimensional data space, the first recursively partitioned/nested

8 geometric structure being corresponding to the first normalized multi-
9 dimensional data space,

0 determine corresponding first graphing values for said first corresponding

1 regions within said first recursively partitioned/nested geometric

2 structure determined for said first normalized multi-dimensional data of
3 said first normalized multi-dimensional data space;

4 associate corresponding first visual attributes with said first corresponding

5 regions within said first recursively partitioned/nested geometric

6 structure, based at least in part on corresponding ones of said

determined first graphing values, and

display said first recursively partitioned/nested geometric structure,

9 visually differentiating said first corresponding regions based at least
20 part on corresponding ones of said associated first visual attributes;

21 and

22 at least one processor coupled to the storage medium to execute the

3.3 programming instructions.

1 40. The apparatus of claim 39, wherein each of said first normalized multi-
2 dimensional data of said first normalized multi-dimensional data space comprises a
3 plurality of relative coordinate values, and the programming instructions are further
4 designed to enable the apparatus to construct a polynary string to represent each of
5 said first normalized multi-dimensional data and its corresponding one of said first
6 regions within said first recursively partitioned/nested geometric structure in
7 accordance with the relative coordinate values.

1 41. The apparatus of claim 40, wherein said programming instructions are
2 designed to enable the apparatus to perform said constructing of a polynary string
3 by selecting a symbol as the next symbolic member of the polynary string based on
4 which of the relative coordinate values is the current highest relative coordinate
5 value.

1 42. The apparatus of claim 41, wherein said programming instructions are further
2 designed to enable the apparatus to perform said constructing of a polynary string
3 by reducing the highest relative coordinate value in by an amount (G), upon each
4 selection, and reducing the amount (G) after each reduction.

1 43. The apparatus of claim 42, wherein said programming instructions are
2 designed to enable the apparatus to set the amount (G) initially to $1 - F$, and
3 thereafter reduced each time by $G^*(1 - F)$, where F equals $(n - 1)/n$, and n equals
4 the number of relative coordinate values.

1 44. The apparatus of claim 40, wherein said programming instructions are
2 designed to enable the apparatus to perform said determining by determining

3 frequencies of occurrence of the various polynary strings of said first normalized
4 multi-dimensional data, and assigning the determined frequencies of occurrence to
5 the corresponding first regions within the first recursively partitioned/nested
6 geometric structure as the determined first graphing values of the corresponding first
7 regions.

1 45. The apparatus of claim 39, wherein said programming instructions are
2 designed to enable the apparatus to perform said determining by assigning first
3 output values corresponding to the first normalized multi-dimensional data as the
4 determined first graphing values of the corresponding first regions within the first
5 recursively partitioned/nested geometric structure.

1 46. The apparatus of claim 45, wherein said programming instructions are further
2 designed to enable the apparatus to perform said determining by computing said
3 first output values.

1 47. The apparatus of claim 46, wherein each of said first normalized multi-
2 dimensional data of said first normalized multi-dimensional data space comprises a
3 polynary string having a plurality of symbols, encoding a plurality of relative
4 coordinate values, and said programming instructions are designed to enable the
5 apparatus to perform said computing by
6 summing one or more appearance values corresponding to one or more
7 appearances of the particular symbol in a polynary string, and adding the sum to an
8 average residual relative coordinate value, and
9 repeating said summing and adding for each constituting symbols of the
10 polynary string.

1 48. The apparatus of claim 47, wherein each appearance value corresponding to
2 an appearance of a particular symbol is dependent on the position of the particular
3 appearance of the particular symbol in the polynary string.

1 49. The apparatus of claim 48, wherein each appearance value corresponding to
2 an appearance of a particular symbol is equal to a positional value associated with
3 the position of the particular appearance in the polynary string.

1 50. The apparatus of claim 49, wherein
2 each positional value equals to $(1 - F) \times F^{**}(k - 1)$, and
3 the average residual relative coordinate value equals $(1 - F) \times F^{**}K$,
4 where F equals $(n - 1)/n$,
5 k denotes a position in a polynary string,
6 n equals the number of relative coordinate values, and
7 K equals the length of the polynary string.

1 51. The apparatus of claim 40, wherein said programming instructions are further
2 designed to enable the apparatus to
3 receive a first zooming specification comprising one or more of said polynary
4 string constituting symbols;
5 exclude a first subset of said first regions based at least in part on said
6 received first zooming specification; and
7 repeat said displaying for the remaining ones of said first regions in an
8 expanded manner.

1 52. The apparatus of claim 51, wherein said programming instructions are further
2 designed to enable the apparatus to
3 receive a second zooming specification comprising one or more additional
4 ones of said polynary string constituting symbols;
5 exclude a second subset of said remaining ones of said first regions based at
6 least in part on said received second zooming specification; and
7 repeat said displaying for the remaining ones of said first regions.

1 53. The apparatus of claim 52, wherein said programming instructions are
2 designed to enable the apparatus to
3 receive an unzoom specification;
4 restore the remaining ones of said first regions to re-include said excluded
5 second subset of said first regions; and
6 repeat said displaying for the remaining ones of said first regions.

1 54. The apparatus of claim 51, wherein said programming instructions are further
2 designed to enable the apparatus to
3 receive an unzoom specification;
4 restore the remaining ones of said first regions to re-include said excluded
5 first subset of said first regions; and
6 repeat said displaying for said first regions.

1 55. The apparatus of claim 39, wherein said programming instructions are
2 designed to enable the apparatus to perform said associating by associating, for
3 each of said first regions, a selected one of a plurality of symbols with the region
4 based at least in part on the determined graphing value of the region.

1 56. The apparatus of claim 39, wherein said programming instructions are
2 designed to enable the apparatus to perform said associating by associating, for
3 each of said first regions, a selected one of a plurality of color attributes with the
4 region based at least in part on the determined graphing value of the region.

1 57. The apparatus of claim 39, wherein said programming instructions are
2 designed to enable the apparatus to perform said associating by associating, for
3 each of said first regions, a selected one of a plurality of colored geometric
4 primitives with the region based at least in part on the determined graphing value of
5 the region.

1 58. The apparatus of claim 39, wherein said programming instructions are
2 designed to enable the apparatus to perform said associating by associating, for
3 each of said first regions, a selected blending of a plurality of colors with the region
4 based at least in part on contributions to the determined graphing value of the
5 region.

1 59. The apparatus of claim 39, wherein said first regions correspond to all
2 constituting regions of the first recursively partitioned/nested geometric structure,
3 said first normalized multi-dimensional data are values of independent variables of a
4 function, and said first graphing values are corresponding values of a dependent
5 variable of the function.

1 60. The apparatus of claim 39, wherein said programming instructions are further
2 designed to enable the apparatus to

3 identify a second plurality of regions within a second recursively
4 partitioned/nested geometric structure that correspond to a second plurality of
5 normalized multi-dimensional data of a second normalized multi-dimensional data
6 space, the second recursively partitioned/nested geometric structure being
7 corresponding to the second normalized multi-dimensional data space;
8 determine corresponding second graphing values for said second
9 corresponding regions within said second recursively partitioned/nested geometric
10 structure determined for said second normalized multi-dimensional data of said
11 second normalized multi-dimensional data space;
12 associate corresponding second visual attributes with said second
13 corresponding regions within said second recursively partitioned/nested geometric
14 structure, based at least in part on corresponding ones of said determined second
15 graphing values; and
16 display said second recursively partitioned/nested geometric structure,
17 visually differentiating said second corresponding regions based at least in part on
18 corresponding ones of said associated second visual attributes.

1 61. The apparatus of claim 60, wherein said first and second recursively
2 partitioned/nested geometric structures are displayed in a manner such that both
3 recursively partitioned/nested geometric structures are visible concurrently.

1 62. The apparatus of claim 61, wherein each of said first and second normalized
2 multi-dimensional data of said first and second normalized multi-dimensional data
3 spaces comprises a polynary string having a plurality of symbols, encoding a
4 plurality of relative coordinate values, said programming instructions are further
5 designed to enable the apparatus to

6 receive a first zooming specification comprising one or more of said polynary
7 string constituting symbols;
8 exclude a first subset of said first regions based at least in part on said
9 received first zooming specification;
10 exclude a second subset of said second regions based at least part on the
11 removed ones of said first regions; and
12 repeat said displaying for the remaining ones of said first and second regions.

1 63. The apparatus of claim 60, wherein said first and second normalized multi-
2 dimensional data are values of first and second input variables.

1 64. The apparatus of claim 60, wherein said first normalized multi-dimensional
2 data are values of input variables, and said second normalized multi-dimensional
3 data are values of corresponding output variables.

1 65. The apparatus of claim 39, wherein said apparatus is a selected one of a
2 palm sized processor based device, a notebook computer, a desktop computer, a
3 set-top box, a single processor server, a multi-processor server, and a collection of
4 coupled servers.

1 66. The apparatus of claim 37, wherein said programming instructions are further
2 designed to compute a location for a centroid for each of a plurality of primitive
3 elements of the geometric structure.

1 67. The apparatus of claim 66, wherein said programming instructions are
2 designed to compute coordinates (x_p, y_p) of the location of each centroid as follows:

3 $X_p = X_c + R * \sum_{k=1}^K V(N, k) * C(N, m[L_k])$

4 $Y_p = Y_c + R * \sum_{k=1}^K V(N, k) * S(N, m[L_k])$

5 where:

6 (X_c, Y_c) are coordinate values of the geometric structure's centroid;

7 R is a radius extending from the geometric structure's centroid to an
8 outermost vertex of the geometric structure;

9 $V(N, k)$ is $w^*(1 - w)^{*(k - 1)}$ where $w = 1/(1 + \sin(\pi/N))$;

10 $m[L_k]$ is outer vertex number (1, 2, ..., N) assigned to the kth symbol
11 appearing in a corresponding polynary string;

12 $C(N, m[L_k]) = \cos(a * \pi)$; and

13 $S(N, m[L_k]) = \sin(a * \pi)$ [where $a = (5*N - 4*m[L_k])/(2*N)$].

1 68. The apparatus of claim 67, wherein said programming instructions are
2 designed to compute the K values of $V(N, k)$ once responsive to a specification of N.

1 69. The method of claim 67, wherein said programming instructions are designed
2 to compute at least the N values of $C(N, m[L_k])$ or the N values of $S(N, m[L_k])$ once
3 responsive to a specification of N.

1 70. An apparatus comprising
2 storage medium having stored therein programming instructions designed to
3 enable the apparatus to
4 associate n symbolic representations with said n relative coordinate
5 values, and

6 select the symbolic representation corresponding to the highest
7 relative coordinate value as the first constituting member of the
8 polynary string representation; and
9 at least one processor coupled to the storage medium to execute the
10 programming instructions.

1 71. The apparatus of claim 70, wherein the programming instructions further
2 enable the apparatus to
3 compute a constant value (F) by dividing $(n - 1)$ by n ; and
4 compute a variable value (G) by subtracting F from 1;
5 subtract G from the current highest relative coordinate value; and
6 select the symbolic representation corresponding to the current highest
7 relative coordinate value as the next constituting member of the polynary string
8 representation.

1 72. The apparatus of claim 71, wherein the programming instructions further
2 enable the apparatus to
3 multiply the current value of G by F;
4 subtract G from the current highest relative coordinate value; and
5 select the symbolic representation corresponding to the current highest
6 relative coordinate value as the next constituting member of the polynary string
7 representation.

1 73. The apparatus of claim 72, wherein the programming instructions further
2 enable the apparatus to repeat said multiply, subtracting and selecting operations
3 set forth in claim 64.

1 74. The apparatus of claim 70, wherein said symbolic representation comprises a
2 letter.

1 75. The apparatus of claim 70, wherein said symbolic representation comprises a
2 special character.

1 76. The apparatus of claim 70, wherein said apparatus is a selected one of a
2 palm sized processor based device, a notebook computer, a desktop computer, a
3 set-top box, a single processor server, a multi-processor server, and a collection of
4 coupled servers.

1 77. An apparatus comprising:
2 storage medium having stored therein a plurality of programming instructions
3 designed to enable the apparatus to
4 determine appearance positions of appearance instances of symbolic
5 members of a polynary string representation of an entity having a
6 number of constituting variables, the symbolic members being
7 corresponding to the constituting variables,
8 sum positional values corresponding to the appearance instances of the
9 symbolic members in said polynary string representation, and
10 add the sum to an average residual relative coordinate value; and
11 at least one processor coupled to the storage medium to execute the
12 programming instructions.

1 78. The apparatus of claim 77, wherein

2 each positional value equals to $(1 - F) \times F^{**}(k - 1)$; and
3 the average residual relative coordinate value equals $(1 - F) \times F^{**}K$,
4 where F equals $(n - 1)/n$,
5 n equals the number of coordinate values,
6 k denotes a position in the polynary string representation; and
7 K denotes the length of the polynary string.

1 79. The apparatus of claim 77, wherein said apparatus is a selected one of a
2 palm sized processor based device, a notebook computer, a desktop computer, a
3 set-top box, a single processor server, a multi-processor server, and a collection of
4 coupled servers.

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